Bunch lengths and Longitudinal Emittances

Notes from Oct 15, 2003 emittance meeting plus additional comments – Draft 1

Purpose of these meetings

1. Understand how well we are measuring emittances in the various machines and improve the measurements where possible. Estimate "error bars".
2. Agree on definitions, particularly for comparing between machines.

Action Items

1. There are a number of things interspersed below, but I don't want to put anything here until next week's meeting. We need to hear the MI situation. I know both Dave M. and Vladimir intend to provide some feedback. I expect "implement Alvin's algorithm for MI, TEV " will be one of them. One question is where – in the SBD itself, or have the SBD supply enough data to do it "offline" (or both).

Next Meeting – October 22, 2003 – 2:00 Huddle

1. Chandra's talk on MI algorithms
2. Tev alogorithm summarized.
2. Answer questions from this meeting
3. Agree on action items, which should include what to put in the Supertable and any changes to SBDs – hopefully not creating even more unfunded mandates….

Uses of measurements

1. for operations - - Supertable, etc.
    a. compare emittances along the chain for a store
    b. compare emittance changes one stage to next versus store
    c. compare emittance (rms?) at a particular stage as a function of store
2. real time during shot setup
3. internal bunch structure – other instruments do this?

Requirements – Need to specify

1. bunch by bunch certainly
2. accuracy

Methods of calculating sigma t

1. sigma from Gaussian fit- Tev only
2. rms calculation – Tev and MI
3. Alvin's ansatz

Methods of calculating emittances, dp/p

1. linear approximation as implemented in MI and Tev SBD. See BD document 518 by Nickolai Kuropatkine. (See summary at end of these notes.) For the next meeting, bob Flora will present the one-page summary for the Tev.
2. Mike Church ansatz for Tev – (BD document 694)
3. Chandra's ansatz for MI – next week. (This is also discussed in Doc 518.)
4. Alvin's expansions – BD note 548 for method ,and today's talk as noted below for store 2997 and comparing to Mike's method.
5. tomography - Andreas
6. Leo's work

Alvin's talk

1. See BD document 548 for method
2. His notes from today will become a document
3. how typical is this store?
4. table summarizing comparison for store 2997. Mike Church will check his 980 equation. SBD numbers added post meeting.

	Alvin	Mike	SBD (T:SBDPES)
150 Gev	3.32	3.65	8.40 (Before ramp)
980 Gev	3.37	4.45	6.18 (remove halo)

"Constants" in emittance calculations – how well known, versus time and between machines?

1. RF voltage
2. eta
3. synchronous energy
4. synchronous phase
5. central frequency

Tev SBD – Bob Flora's talk

1. Problems
    a. Slow
    b. could have better S/N
    c. problem identifying satellites
    d. code uses integer arithmetic
    e. limited by baseline accuracy
2. Planned improvements
    a. change code to reals (problems d,e)
    b. average N samples. 4<N<16, at 125 microsecond intervals (problems a,b,e)
    c. get p, pbar from same data and acquire data on high and low gain at same time (problems a,c,e)
    d. Use live RF frequency time offset in offset calculations. (I don't understand this.)
    e. Make analysis and acquisition concurrent. (problem a)

f. Make access to data at each analysis step easier
g. 30% complete – what is the estimate for completion?

3. Comments from audience
   a. how good is the time base in scope relative to RF frequency? Ans: 1hz in 53 MHZ
   b. how is the scope triggered? Ans: from LLRF. Stephen Pordes will document for the next meeting.
   c. effect of trigger jitter. Ans: from Stephen. The scope gives you the time between the trigger and edge of the digitization bin, i.e. the time within the .5 ns.
   d. should average over synchrotron period , on order of a few milliseconds, which is close to N=10 in point 2 b above.
   e. what about uncoalesced beam?
   f. what scopes? Should they be upgraded?
      i. Tev Scope - LeCroy 9384L
         1. SINGLE 4 GS/s 4 Mpt
         2. QUAD 1 GS/s 1 Mpt
      ii. MI Scope , LeCroy LC584AM
         1. SINGLE 8 GS/s 2 Mpt
         2. QUAD 2 GS/s .5 Mpt
   g. Dave McGinnis – "Should only take a month to implement the Alvin method. We should do it. We should buy a new scope. Editorial comment by Jean – "Yes, but what about MI? We need to be able to compare apples and apples. Mi is more complicated with coalesced and uncoalesced beam. Can the Alvin methods be ported easily to MI signals?"

Summary of Nickolai's work from last longitudinal emittance meeting (Dec 20, 2002) – See BD Doc 518.

- SBD studies - Nickolai Kuropatkine.
  - Nickolai showed plots in which he compared the emittance and dp/p as reported by the SBD with what he gets by re-calculation from the sigma as reported by the SBD. He did this in both the Tevatron and the MI. He gets good agreement between his recalculation and the SBD value, modulo a factor of 2 in the MI (see comment from Alan below) and a small offset dues to a correction for cable dispersion which may or may not be appropriate, judging from comments at the meeting.
  - Comment from Alan Hahn after the meeting:
    Upon reflection about the longitudinal emittance reported by the SBD, I think the apparent factor of 3 is simply due to the SBD actually folding in "pi" in the calculation, and FNAL longitudinal emittance leaving it out (but I am not positive--unlike transverse emittance which is explicitly reported as "pi mm mr", the long emittance is reported as "eV-s"). Someone can correct me if I am

wrong. Anyway, the value reported is the 95% value (=6pi*dE*dt), assuming a bi-Gaussian distribution. (bi-Gaussian = 2d gaussian f(x,y)=A*exp(-0.5*[(x/sx)^2+y/sy)^2]